FELIPPE BEVILACQUA PRADO

ALTERAÇÕES MORFOLÓGICAS DOS SEIOS FRONTAL E ESFENOIDAL E DO ESPAÇO AÉREO FARÍNGEO APÓS CIRURGIA ORTOGNÁTICA PARA CORREÇÃO DE PACIENTES CLASSE II.

Dissertação apresentada à Faculdade de Odontologia de Piracicaba, da Universidade Estadual de Campinas para obtenção do Título de Mestre em Biologia Buco Dental, área de concentração Anatomia.

Orientador: Prof. Dr. Paulo Henrique Ferreira Caria

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Resumo

A cirurgia ortognática tem sido regularmente usada no tratamento das deformidades dentofaciais, porém, seus efeitos sobre os tecidos moles e duros adjacentes ainda não estão totalmente esclarecidos. O objetivo desse estudo é avaliar cefalometricamente as alterações morfológicas dos seios frontal e esfenoidal e do espaço aéreo faríngeo superior e inferior em indivíduos com maloclusão classe II, submetidos à cirurgia ortognática com avanço maxilomandibular. Foram avaliados 49 pacientes (98 telerradiografias laterais), nos períodos pré- operatório (01 semana antes da cirurgia) e pós-operatório (seis meses após a cirurgia). Foram realizadas as medidas lineares: Nasofaringe (TB-PhW1), Orofaríngе (TU-PhW2), ENA-Me, N-Me e S-Go e as medidas angulares SNA, SNB e Gonial além das dimensões dos seios frontal e esfenoidal em cada telerradiografia lateral. Os resultados foram submetidos ao *test t de Student* para avaliar as diferenças entre os dois momentos operatórios. Todas as medidas mostraram replicabilidade excelente para o intraclass correlation coefficient (ICC) (ICC>0,9; p<0,0001). Houve aumento das medidas TB – PhW1 e TU – PhW2 e diminuição das dimensões dos seios frontal e esfenóide após a cirurgia ortognática (teste t, p<0.0001). A cirurgia ortognática com avanço maxilomandibular altera a morfologia do espaço aéreo faríngeo superior e inferior e dos seios frontal e esfenoidal em indivíduos com má oclusão classe II após seis meses de correção.

Palavras - Chaves: Máoclusão Classe II de Angle, Seio Frontal, Seio Esfenóide, Biomecanica.

Abstract

Orthognathic surgery has been regularly used in the treatment of dentofacial deformities; however, their effects on adjacent structures are not completely clarified. The purpose of this study was to evaluate cephalometrically the morphologic alterations of the frontal and sphenoid sinuses and superior and inferior pharyngeal airway space in class II malocclusion patients, after maxillomandibular advancement. The study included 48 patients (96 lateral teleradiographs) analyzed in the preoperative (1 week before surgery) and postoperative (six months after surgery) periods. In each lateral teleradiography, the linear measurements made were TB-PhW1 (nasopharynx), TU-PhW2 (oropharynx), ANS-Me, N-Me and S-Go, the angular measurements were SNA, SNB and gonial, and the dimensions of the frontal and sphenoid sinuses were determined. The results were submitted to Student's t-test to evaluate the differences between the two operative times. The intraclass correlation coefficient (ICC) showed excellent reproducibility (ICC>0.9; $p<0.0001$) for the measurements. There was an increase in the measurements TB – PhW1 and TU – PhW2 and decrease of the dimensions of the frontal and sphenoid sinuses after orthognathic surgery. In conclusion, the orthognathic surgery consisting of maxillomandibular advancement alters the morphology of the pharyngeal airway space, superior and inferior, and of the frontal and sphenoid sinuses in individuals with class II malocclusion after six months of correction.

Key words: Malocclusion, Angle Class II, Frontal Sinus, Sphenoid Sinus, Biomechanic.

SUMÁRIO

INTRODUÇÃO GERAL

A Biomecânica do Esqueleto Facial e os Seios Paranasais.

De acordo com a lei de Wolff, as mudanças na função e na intensidade das forças mecânicas aplicadas aos ossos podem modificar externa e internamente sua morfologia (Wolff, 1884). Seguindo esse conceito, a biomecânica facial avalia a influência das forças mecânicas mastigatórias sobre o osso alveolar e estruturas de suporte craniofacial (Sicher, 1965) com base na remodelação óssea (Misch & Bidez, 1997).

Os seios paranasais são espaços localizados nas paredes laterais da cavidade nasal, contidos pelo esqueleto facial, que se remodelam em decorrência às demandas funcionais mastigatórias, e sofrem influência de acordo com fatores genéticos, geográficos, climáticos e raciais (Blanton & Biggs, 1969).

A relação entre a presença da região supra-orbital e a demanda funcional mastigatória (Prossinger, 2003), vem aumentando as discussões sobre a variabilidade morfológica dos seios paranasais nas diferentes populações humanas, já que esse aspecto é apontado como um dos principais responsáveis pela remodelação óssea dessa estrutura (Hylander, 1999).

Estudos experimentais realizados em primatas demonstraram que a região supra-orbital suporta consideráveis quantidades de forças mecânicas mastigatórias, e que os seios paranasais, aumentam de dimensões na ausência de estímulos mecânicos (Preuschoft *et al*, 2002).

Observações feitas em algumas espécies de mamíferos verificaram seios maxilares com a presença de septos verticais, que invadem estruturas vizinhas, como o osso frontal e o esfenóide, sendo de grande importância funcional no suporte e na dissipação das cargas mecânicas mastigatórias (Koppe *et al.,* 2005).

Diante da escassez de evidências cientificas sobre o assunto, permanece duvidoso se as alterações morfológicas dos seios paranasais são determinadas por fatores mecânicos, funcionais ou pela própria arquitetura facial.

A Cirurgia Ortognática e a Biomecânica do Esqueleto Facial.

As ma-oclusões e deformidades craniofaciais são alterações morfológicas do crescimento e desenvolvimento do esqueleto cefálico resultante de mutações gênicas, que alteram a harmonia do complexo craniofacial (Mao & Nah, 2004). A ma-oclusão Classe II de Angle apresenta maior proporção dentre as demais deformidades dentofaciais, segundo Burden *et al.* (2007), caracterizando-se pelo posicionamento posterior da mandíbula em relação à maxila ou pela atrofia mandibular (Faltin, 1999).

Apesar de corrigir tais discrepâncias, a cirurgia ortognática traz conseqüências sobre o espaço aéreo faríngeo dependendo da modalidade cirúrgica, pois, enquanto o avanço mandibular aumenta as dimensões desse espaço (Riley *et al.,* 1987; Li *et al.* 1999), o recuo mandibular o estreita ainda mais (deBerry-Borowiecki *et al*. 1988; Tselnik e Pogrel, 2000).

Se por um lado os benefícios funcionais da cirurgia ortognática em relação à função mastigatória e outros fatores estão bem esclarecidos (Thrckomorton, 1984) por

outro, as conseqüências indiretas sobre a morfologia dos seios paranasais, ainda não, uma vez que as forças mecânicas geradas pelos músculos da mastigação e dentes, estimulam e ativam a formação óssea direta ou indiretamente nesses tecidos dento esqueléticos (Mavropoulos *et al*. 2004), indicativo de uma relação entre função mastigatória muscular e adaptação esquelética craniofacial (Langenbach *et al*. 2002; Farella *et al.* 2003).

Frente à revisão realizada observou-se escassez de parâmetros para a avaliação das alterações morfológicas craniofaciais. Neste estudo, que será apresentado em forma de capítulo a seguir, buscou-se avaliar cefalometricamente, as possíveis alterações morfológicas dos seios frontal e esfenoidal e do espaço aéreo faríngeo em pacientes com má oclusão tipo Classe II de Angle, submetidos à cirurgia ortognática.

CAPÍTULO 1*

Title: MORPHOLOGICAL CHANGES OF THE FRONTAL AND SPHENOID SINUSES AND PHARYNGEAL AIRWAY SPACE AFTER ORTHOGNATHIC SURGERY FOR CLASS II CORRECTION

Article Type: Research Paper

Keywords: Malocclusion, Angle Class II; Frontal Sinus; Sphenoid Sinus; Pharyngeal Airway Space; Biomechanic; Mandibular Advancement.

Corresponding Author: Dentistry felippe prado,

First Author: Felippe B Prado, MSc

Order of Authors: Felippe B Prado, MSc; Paulo Henrique F Caria, DDS, MSc, ScD, Assistant Professor.; Fracisco C Groppo, DDS, MSc, ScD, Chairman; Claudio Jodas, MSc, Assistant Professor.

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Abstract

Orthognathic surgery has been regularly used in the treatment of dentofacial deformities; however, their effects on adjacent structures are not completely clarified. The purpose of this study was to evaluate cephalometrically the morphologic alterations of the frontal and sphenoid sinuses and superior and inferior pharyngeal airway space in class II malocclusion patients, after maxillomandibular advancement. The study included 48 patients (96 lateral teleradiographs) analyzed in the preoperative (1 week before surgery) and postoperative (six months after surgery) periods. In each lateral teleradiography, the linear and angular measurements made were TB-PhW1, TU-PhW2, ANS-Me, N-Me, S-Go and SNA, SNB, gonial, respectively, and the dimensions of the frontal and sphenoid sinuses were determined. The differences between the two operative times results were evaluate by *Student's t-test*. All measurements showed excellent reproducibility for the intraclass correlation coefficient (ICC>0.9; p<0.0001). There was an increase in the measurements TB – PhW1 and TU – PhW2 and decrease of the dimensions of the frontal and sphenoid sinuses after orthognathic surgery. In conclusion, the maxillomandibular advancement alters the morphology of the pharyngeal airway space, superior and inferior, and of the frontal and sphenoid sinuses in class II patients after six months of correction.

Key words: Malocclusion, Angle Class II; Frontal sinus; Sphenoid Sinus; Pharyngeal Airway Space; Biomechanic; Mandibular Advancement.

Introduction

Malocclusions and craniofacial deformities are morphologic alterations related to the growth and development of the facial skeleton and resultant from genetic polymorphisms that alter the harmony of the craniofacial complex11.

It has been show1, that malocclusion of the Angle class II type is the most common dentofacial deformity, characterized by the retrusive position of the mandible in relation to the maxilla or by mandibular atrophy.

Orthognathic surgery is capable of correcting dentofacial discrepancies, modifies the maxillo-mandibular relation, but and its effects on dimensions of the pharyngeal airway space4, 13 and other areas of the cranium such as paranasal sinuses, are still not totally known.

Surgical procedures such as mandibular advancement increases the dimensions of the pharyngeal airway space8, while mandibular setback narrows it even more24.

In 2004, Mavropoulos12 affirmed that the mechanical forces generated by the mastication muscles stimulate the formation of bone tissue directly or indirectly, showing the intrinsic relation between the distribution of masticatory forces and the shape of the craniofacial skeleton.

Because of the maxillo-mandibular alterations caused by orthognathic surgeries and the direct relation between masticatory force and the shape of the craniofacial skeleton, the aim of this study was to evaluate the possible morphologic modifications of the craniofacial skeleton of patients with class II malocclusion submitted to maxillomandibular

advancement with counterclockwise rotation, taking as references the area of the frontal and sphenoid sinuses and pharyngeal airway space.

Materials and Methods

Sample (Criteria for inclusion and exclusion)

A total of 98 lateral teleradiographs of 49 patients (36 women and 13 men) with occlusal alteration of the Angle class II maloclusion, were analyzed in the preoperative (one week before surgery) and postoperative (6 months after surgery) periods. The mean age of the patients was 26.5 (±4.4) years for the women and 24.8 (±3.4) years for the men. We selected only patients who showed complete permanent dentition and absence of craniofacial deformities.

Lateral cephalometric radiographs were obtained with the patient's head in the cephalostat position in accordance with the following orientation: Frankfurt horizontal plane (tragus-infraorbital foramen line) parallel to the floor and mid-sagittal plane perpendicular to the horizontal plane; teeth in maximal habitual intercuspidation; lips relaxed and in natural position; vertebral column erect; olives of the cephalostat duly encased in the external acoustic meatus and nasion of the cephalostat, in the region of the frontonasal suture corresponding to the nasion point. This positioning is recommended for obtaining lateral teleradiographic images, thereby making it possible to standardize them and record them at different times.

Methods for evaluating the areas of the frontal and sphenoid sinuses

The contour of the frontal and sphenoid sinuses of each lateral teleradiograph was outlined on a sheet of tracing paper on a table X-ray viewer (Konex® 25x30cm), according

to the criteria of Erturk5, and Ferreira & Oliveira6, (Figures 1 and 2), respectively. Also added was a standard reference measure of 1 cm, required for application of the software.

Insert figure 1

Insert figure 2

Based on the outline of the areas of the frontal and sphenoid sinuses, the images were digitized on a scanner with a transparency reader (Microtek International., Inc. No. 6, Industry. East Road 3. Science-based Industry Park. Hsinchu, Taiwan), model Scan Maker II SP, calibrated for gray scales, with a resolution of 300 dpi and 100% image size. Later, the images were differentiated into distinct colors by means of the software Microsoft ® PAINT (Versão 5.1), USA, to facilitate their analysis.

After the definition of the area of the frontal and sphenoid sinuses in each teleradiograph, the area of each image was calculated, and the number of pixels was converted into square centimeters (cm2) by the software SIARCS 3.0 (Sistema Integrado para Analise de Raizes and Cobertura do Solo), version 3.0, developmed by Embrapa (CNPDIA), Brasilia, DF – Brazil.

Evaluation of the pharyngeal airway space, superior and inferior, and of the craniofacial skeleton:

The lateral teleradiographs were copied with the help of a scanner with a transparency reader, Arcus II® from AGFA (Agfa-Gevaert, NV), with a fixed resolution of 1200 dpi and 100% scale in the Sharp Black and White Photo mode, and afterward transferred to the software Corel 8 Photo-Paint® (Corel Corporation Limited, Dublin,

Ireland), responsible for the capture and new transfer of the image to the software Radiocef 2.0® (Radio Memory Ltda., Belo Horizonte, MG, Brazil) where the following points were traced and measured:

Skeletal points: sella (S) – point situated in the geometric center or the sella turca; nasion (N) – most anterior point of the frontonasal suture; Point A – deepest point of the outline of the pre-maxilla, between the anterior nasal spine and porion; Point B: deepest point in the most internal part of the contour of the mandible in the region between the incisors and menton; Gonion (Go) – pointed located at the intersection of the angle bisector formed by the tangents of the posterior and inferior borders of the mandible with the gonial angle; Menton (Me) – point located at the intersection between the outer cortical bone of the menton and the lower cortical bone of the mandibular body; Anterior nasal spine (ANS) – point situated at the end of the anterior nasal spine.

Pharyngeal points according to Ramesh et al.,18.

TB - Point on posterior aspect of tongue closest to dorsal pharyngeal wall.

UP - Point on posterior aspect of soft palate closest to dorsal pharyngeal wall.

PhW1- Point on dorsal pharyngeal wall closest to TB.

PhW2- Point on dorsal pharyngeal wall closest to UP.

The linear measurement between TB and PhW 1 was calculated parallel to the Frankfort horizontal plane preoperatively and postoperative at an interval of 3 months.

Similarly linear measurement between UP and PhW2 was calculated parallel to Frankfort horizontal plane preoperatively and postoperatively at an interval of 3 months.

Preoperative and postoperative SNA, SNB and gonial angles, were measured and recorded. Similarly, preoperative and postoperative linear measurements for menton-ANS (LAFH - lower anterior facial height), menton-nasion (AFH - anterior facial height), sella-gonion (PFH - posterior facial height) were measured and recorded.

All linear and angular measurements and determination of the area of the frontal and sphenoid sinuses were performed three times by the same examiner experienced in the procedure, and with an interval of two weeks between measurments.

Analysis of data

The data were tabulated and submitted to *Student's t-test*, with the level of significance set at 5%, using the software BioEstat 5.0 (Fundação Mamiramua, Belém, PA). The reproducibility of the measurements was determined by the intraclass correlation coefficient test (ICC).

Results

Difference between the mean age of women and men was not significant (t-test, p=0.2174). All linear and angular measurements showed excellent reproducibility (ICC>0.9; p<0.0001), indicating that the measurements taken by the operator were reproducible and reliable.

Figure 3 shows the means of the pre- and postoperative measurements of TB – PhW1 and TU - PhW2.

Insert figure 3

The analysis of the data (t-test) demonstrated that there were statistically significant differences between the two operative times considering the measurements TB – PhW1 (p= 0.0007) and TU – PhW2 (p< 0.0001).

Figures 4 and 5 showed the means for the pre- and postoperative measurements of SNA, SNB and gonial, respectively.

Insert figure 4

Highly significant differences were observed between the two operative times for the measurements SNA and SNB (p< 0.0001). However, there was no statistically significant difference between the two operative times for the gonial measurement (p= 0.1184).

Figure 5 shows the means of the pre- and postoperative measurements ANS-menton, menton-nasion, sella-gonion.

Insert figure 5

The analysis of the results showed that the measurements ANS-menton, menton-nasion, sella-gonion do not show statistically significant differences between the two operative times (t-test, $p>0.05$).

Figure 6 shows the means of the measurements of the areas of the frontal and sphenoid sinuses before and after surgery.

Insert figure 6

The analysis of the results shows that the measurements obtained in both sinuses, frontal and sphenoid, showed highly significant differences between the two operative times (t-test, $p<0.0001$).

Discussion

Despite the pharyngeal airway space being three-dimensional, in the present study, it was evaluated by radiographic cephalometry by allowing its morphologic visualization at low cost, minimal exposure to radiation15, and mainly the validation of this method, obtained by the optimal correlation between its dimensions measured in lateral teleradiographs, two-dimensionally, and in three-dimensional computerized tomography scans20.

In accordance with Ferreira6, the normal values of the inferior pharyngeal airway space in teleradiographs are 10 to 12 mm. In this study, there was a significant increase in the size of this space (TB–PhW1) in the postoperative (p= 0.0007) which was from 11.89 mm to 13.63 mm. Previous works3, 19 also reported a dimensional increase in this space after maxillomandibular advancement. Pereira Filho *et al.*, 16 also showed an enlargement of this region in 70% of the cases evaluated, an effect produced by the anterior repositioning of the supra-hyoid musculature and of the hyoid bone. As the inferior pharyngeal airway space is surrounded by soft tissue and the mandible, depending on the volume and position of these tissues15, the amount of movement of the posterior wall of the ramus of the mandible in the antero-posterior direction determines the greater or lesser increase in the dimensions of this space13.

In the study of Ferreira6 the normal values for the size of the superior pharyngeal airway space, based on lateral teleradiographs of the cranium, were 17.4 mm in individuals with permanent dentition. Despite that this value was less than that obtain in the present

study, the superior pharyngeal airway space increased from 17.82 mm to 20.23 mm after surgery. The results of our study are similar to those reported previously 3, 16 and such finding can be attributed to the advancement of the soft palate and pharynx after maxillary advancement9.

Authors including Tumbull & Battagel25 and Mehra13 observed an increase in the dimensions of the pharyngeal airway space, from six to fourteen months after maxillomandibular advancement, but, in a longitudinal study, was observed instability in the dimensions of this space twelve years after surgical intervention, with diminution of its dimensions to lower values or close to preoperative values4.

One of the current clinical indications of maxillomandibular advancement surgery is the treatment of patients with obstructive sleep apnea syndrome19, since it augments the dimensions of the pharyngeal airway space, as observed in the present study and strengthens the supra-hyoid and palatopharyngeal musculature to alter its bone fixations, interrupting its repetitive collapse, and consequently reducing hypopnea and apnea, normalizing even cardio-respiratory functions10.

The dimensional alterations of the frontal and sphenoid sinuses after orthognathic surgery have never been employed as a reference for the evaluation of the morphofunctional modifications resulting from modifications in the maxillomandibular relation. No report of the use of this analysis was found in the specialized scientific literature. However, the present study demonstrated the existence of dimensional alterations of these sinuses, as shown in Figure 6.

According to Moss14, the craniofacial skeleton is formed by an assembly of inter-related skeletal units, where the modifications that occur in one region affect other distant areas. Similarly, Sicher22 stated that the masticatory forces act on the craniofacial skeleton remodeling and modifying its structure. Based on the concepts defined by the authors cited, Throckmorton & Ellis23 affirm that after surgical correction a more harmonic maxillomandibular relation is established, promoting a significant improvement in the performance of the stomatognathic system with a consequent increase in the number of occlusal contacts and strength of the bite, aspects that can favor the dissipation of tension by the craniofacial skeleton.

The diminution of the area of the frontal and sphenoid sinuses (Figure 6) after surgical correction, observed in the present study can be attributed to the bone remodeling of their adjacent walls which thicken in relation to biomechanical readaptation of the stomatognathic system. The newly established maxillo-mandibular relation increased the number of occlusal contacts favoring the transmission of the greater amount of mechanical tension, improving the craniofacial architecture17. It should be pointed out that the paranasal sinuses are functional spaces surrounded by thin walls of compact bony substance, located between bony pillars17, which respond to biomechanical requirements of the craniofacial architecture27 and resist masticatory stress, counter-balancing the forces of tension and compression to which they are submitted21.

It is important to point out that the bony tissue is highly organized and complex, composed of an extracellular matrix, organic and inorganic components and a series of cells

responsible for its maintenance3, whose principal function is to provide structural resistance suitable for functional demand. Therefore, the bones adapt extraordinarily well to functional alterations by means of their plasticity8. In addition, the cephalic skeleton works synergistically with the mastication muscles, articulations and teeth, and mechanical tension is the key element capable of increasing or decreasing bone formation26, aspects that explain clearly the dimensional modifications found in the frontal and sphenoid sinuses in this study.

In conclusion this study shows thas there was an alteration in the dimensions of the pharyngeal airway space, superior and inferior, and of the frontal and sphenoid sinuses six months after surgical correction by maxillomandibular advancement in patients with Angle class II malocclusion, and, it is possible to evaluate the craniomandibular alterations of orthognathic surgeries by means of measurements of the frontal and sphenoid sinuses in lateral teleradiographic images.

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Captions to Ilustrations

Figure 1. Outline of the periphery of the frontal sinus on lateral cephalograms accordin to criteria of Erturk (1968) 5. S (Sella point), N (Nasion point), Sh ( ) and Sl ( ).

Figure 2. Outline of the periphery of the sphenoid sinus on lateral cephalograms accordin to criteria of Ferreira & Oliveira (2000) 6.

Figure 3. Means (± standard deviation) of the measurements TB – PhW1 (nasopharynx) and TU – PhW2 (oropharynx) at the two operative times (t-test).

Figure 4. Means (± standard deviation) of measurements SNA, SNB and gonial at the two operative times (t-test).

Figure 5. Means (± standard deviation) of the measurements ANS-menton, menton-nasion, sella-gonion (ANS–Me, N–Me and S–Go, respectively) at the two operative times (t-test).

Figure 6. Means (± standard deviation) of the means of the frontal and sphenoid sinuses before and after surgery (t-test).

FIGURE 1

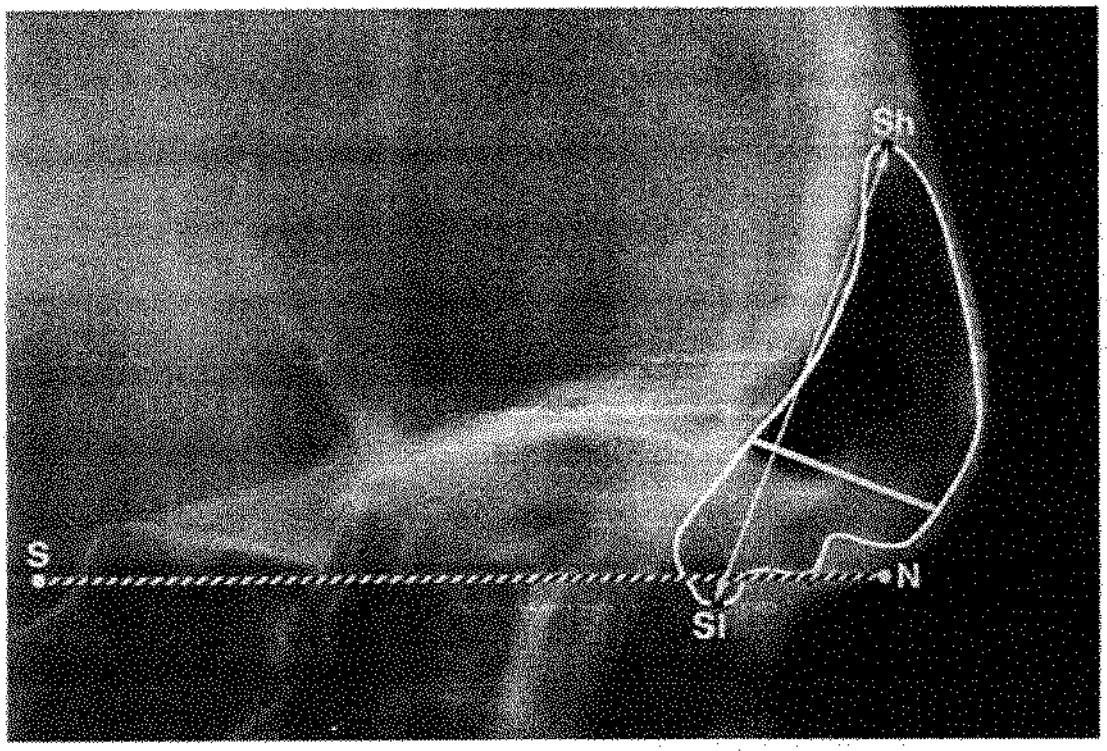


FIGURE 2

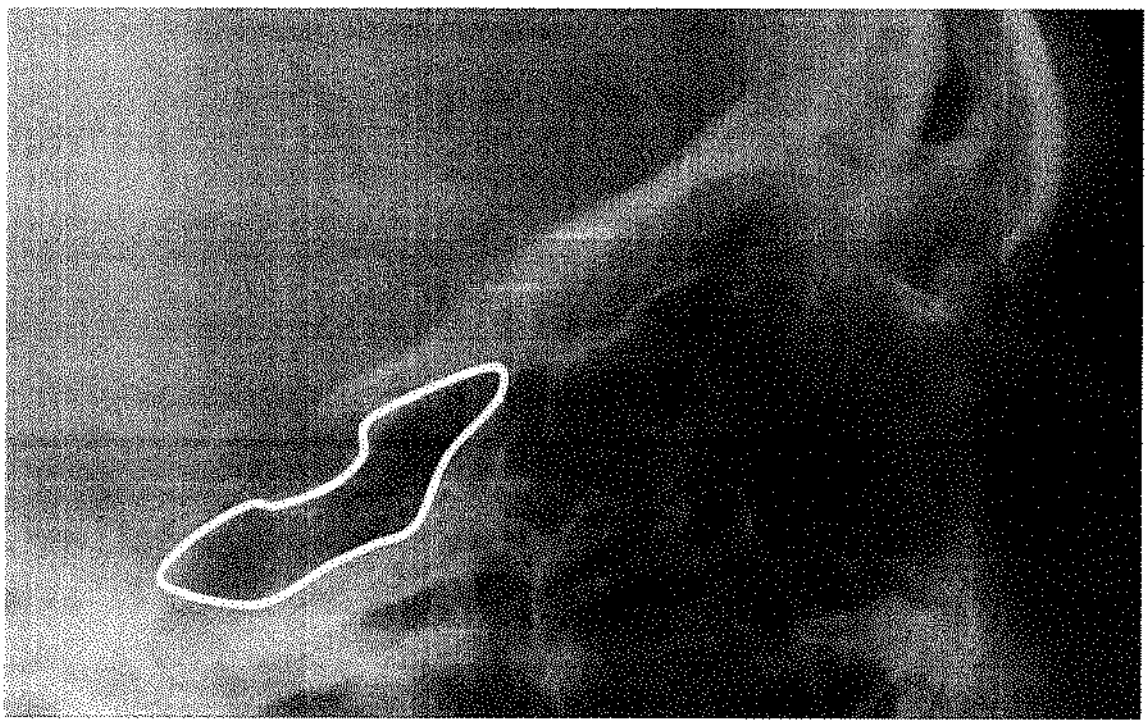


FIGURE 3

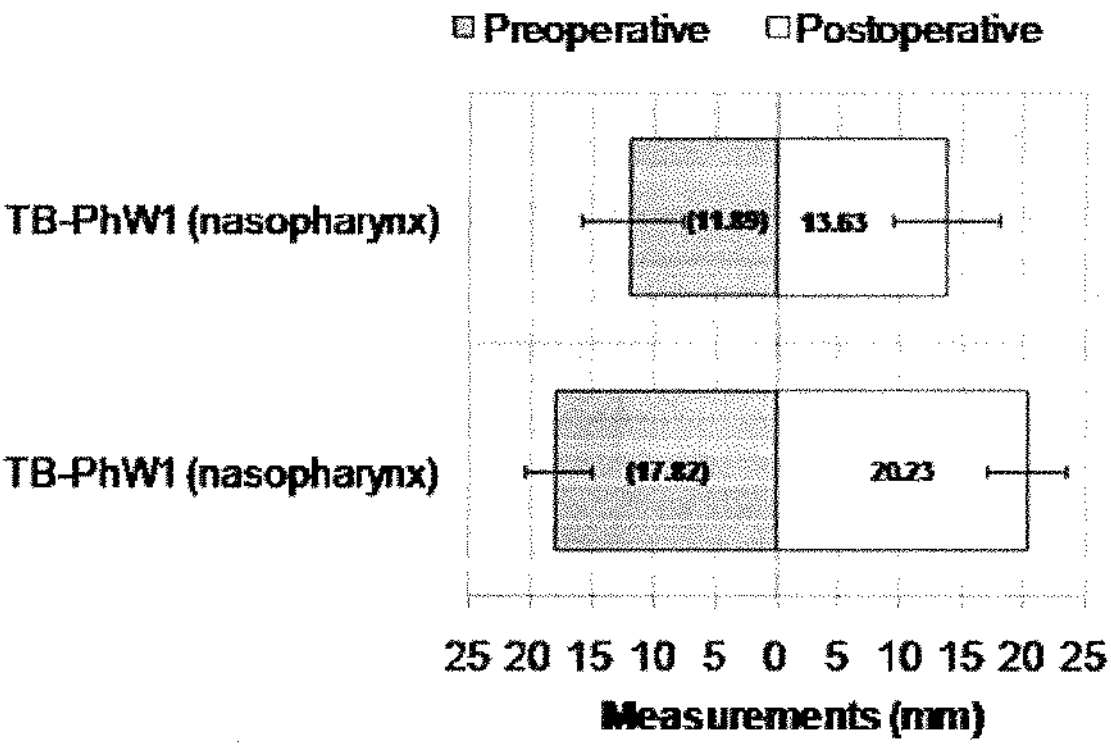

Preoperative
Postoperative
TB-PhW1 (nasopharynx)
(11.83)
13.63
TB-PhW1 (nasopharynx)
(17.87)
20.23
25 20 15 10 5 0 5 10 15 20 25
Measurements (mm)

FIGURE 4

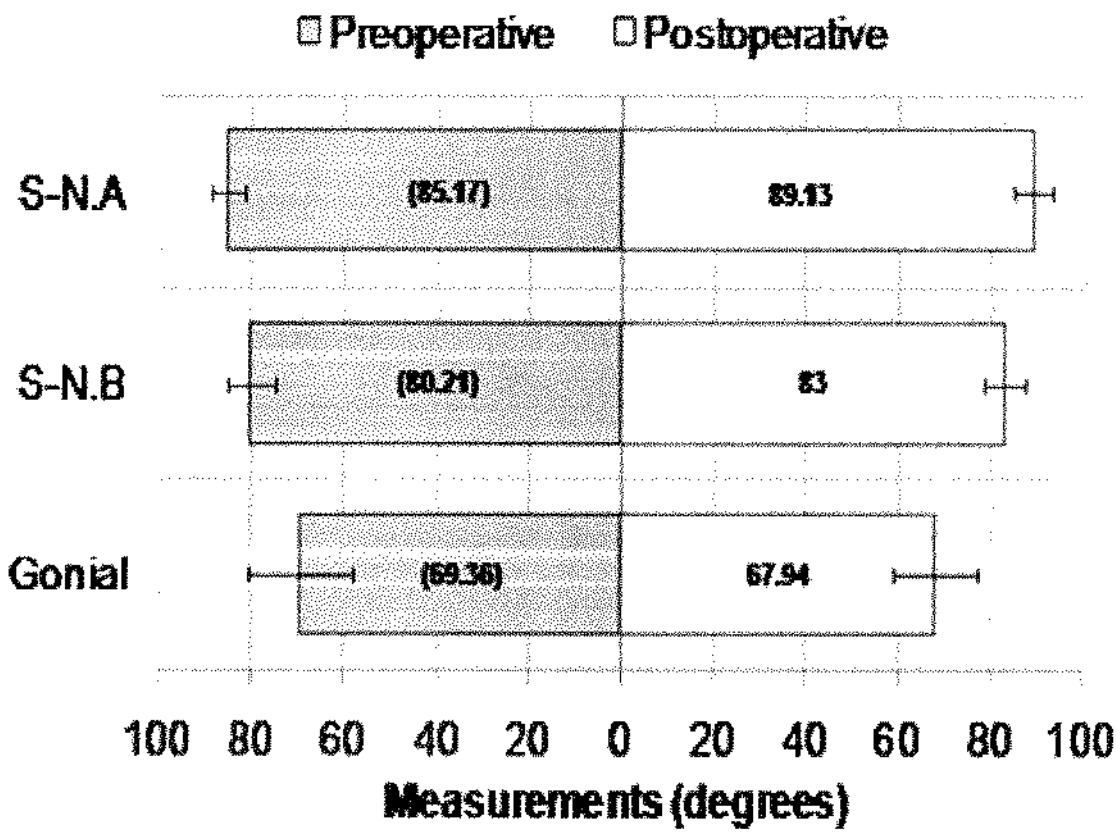

Preoperative
Postoperative
S-N.A
(85.17)
89.13
S-N.B
(80.21)
83
Gonial
(69.36)
67.94
100 80 60 40 20 0 20 40 60 80 100
Measurements (degrees)

FIGURE 5

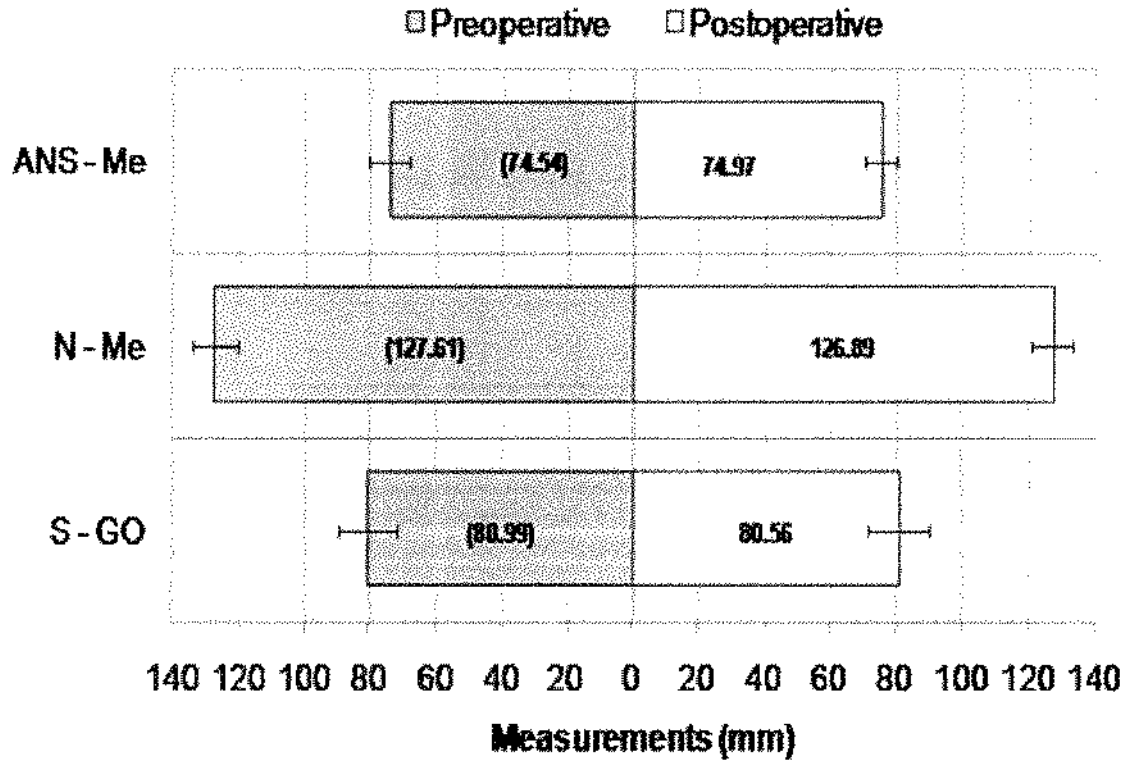
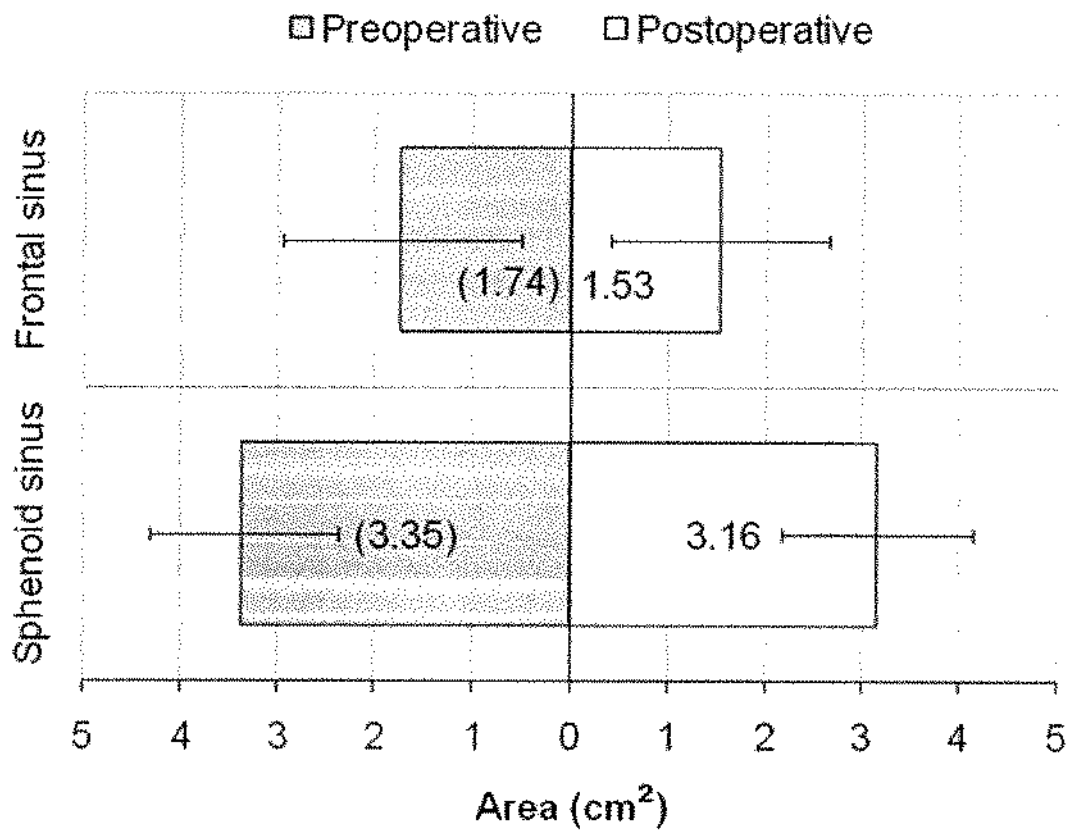

Preoperative
Postoperative
ANS - Me
(74.54)
74.97
N - Me
(127.61)
126.89
S - GO
(80.99)
80.56
140 120 100 80 60 40 20 0 20 40 60 80 100 120 140
Measurements (mm)

FIGURE 6


Preoperative
Postoperative
Frontal sinus
Sphenoid sinus
(1.74)
1.53
(3.35)
3.16
5
4
3
2
1
0
1
2
3
4
5
Area (cm²)

CONCLUSÕES

Analisando os dados obtidos neste estudo pode-se concluir que:

· Houve alteração das dimensões do espaço aéreo faríngeo superior e inferior e dos seios frontal e esfenoidal 6 meses após de correção cirúrgica de avanço maxilomandibular em pacientes com alteração oclusão do tipo Classe II de Angle.

· Por meio da metodologia proposta é possível avaliar as alterações craniomandibulares decorrentes das cirurgias ortognáticas por meio de medidas dos seios frontal e esfenoidal em teleradiografias laterais.

· Este estudo mostra que o espaço aéreo faríngeo e os seios frontal e esfenoidal são significantemente afetadas pelas alterações do esqueleto craniofacial decorrente da cirurgia ortognática.

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RG Nº 4134014-2
ORIENTADOR